MAR 15 1978

NS 1.2:Ex 8/2

Division of

POLICY RESEARCH & ANALYSIS

COMPLETED

ORIGINAL

PROGRAM ANNOUNCEMENT FOR EXTRAMURAL RESEARCH

FISCAL YEAR 1978

November 1977

Scientific, Technological, and International Affairs Directorate
National Science Foundation Washington, D.C. 20550

45

TABLE OF CONTENTS

I. INTRODUCTION AND OBJECTIVES 1

II. SUMMARY OF RESEARCH TOPICS 2

A. Socioeconomic Effects of Science and Technology 2

B. Innovation Processes and Their Management 2

C. Environment, Energy and Resources 3

D. Technology Assessment 3

E. Special Projects 4

III. DETAILED DESCRIPTION OF EXTRAMURAL RESEARCH TOPICS 5

A. Socioeconomic Effects of Science and Technology 5

1. The Contribution of Private and Public Investment in Science and Technology to Economic Performance 5

2. Distribution of Economic Costs and Returns from Science and Technology 7

3. Net Benefits to Society from Technological Innovation 8

4. Effects of Science and Technology on U.S. Private Sector International Transactions 10

5. Effects of Technological Change on Individuals and Social Institutions 11

B. Innovation Processes and Their Management 14

1. Decisionmaking in the Private Sector Leading to Innovation 15

2. Decisionmaking in State and Local Government Leading to Innovation 17

3. Institutional Roles and Linkages in Innovation Processes 17

4. Federal Civilian R&D Management 18

5. Comparative Studies of Innovation Support Policies across Industrial Countries 20

6. Technology Transfer Processes Involving Developing Countries 20

7. Role of Entrepreneurs and Small Firms in Technological Innovation 21

C. Environment, Energy and Resources 22

1. Interactions among Energy, Resources, Population, and Environment 22

2. Economic and Social Effects of Energy Development Activities 23

3. Alternative Modes of Federal Action Related to Environmental Protection, and Their Secondary Effects 23

4. Effects of Environmental Regulations on Industry 24

5. Adequacy and Utilization of the Scientific and Technical Base for Federal Environmental Policies and Regulatory Actions 24

IV. PROGRAM GUIDELINES AND PROCEDURES 27

A. Program Policies 27

Types of Project Supported 27
Eligibility 27
Types of Awards 27
Notification of Awards 28

B. Proposal Development and Submission 28

Letters of Interest 28
Preliminary Proposals 28
Final Proposals 28
Target Dates 29
Proposal Format and Content 29
Cost Sharing 30
Allowable Costs 30
Privileged Information 32
First-Time Applicants 32
Small Business Applicants 33

C. Proposal Evaluation 34

Procedures 34
Criteria for Evaluation 34

D. Reports and Publications 35

Evaluation of Project Output 36

E. Project Monitoring and Administration 37

Appendices:

A. Suggested Cover Sheet for Proposals
B. NSF Budget Form
C. Summary of Completed Project Form

Blank Page

NATIONAL SCIENCE FOUNDATION
DIRECTORATE FOR SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS
DIVISION OF POLICY RESEARCH AND ANALYSIS

PROGRAM ANNOUNCEMENT FOR SUPPORT OF EXTRAMURAL RESEARCH THROUGH SEPTEMBER 30, 1978

I. INTRODUCTION AND OBJECTIVES

This Program Announcement describes the fiscal year 1978 extramural research interests of the National Science Foundation's Division of Policy Research and Analysis (PRA). The work of the Division is a cooperative effort involving intramural analysis by the Division staff supplemented by a limited number of extramural grants and contracts. Research proposals are encouraged in four areas:

° Socioeconomic Effects of Science and Technology

° Innovation Processes and Their Management

° Environment, Energy and Resources

° Technology Assessment

Up to $4.5 million is available in FY 1978 for research on topics described in this announcement. Section II briefly describes the major research areas. Section III provides background information on these research topics, and suggests research approaches and methods which might be appropriate for studies on these topics. Section IV describes the program policies and procedures for submitting proposals. Persons interested in submitting proposals are encouraged to read the detailed descriptions of the research topics before discussing their research interests with the program staff.

The objectives of the Division are derived from the science and technology policy interests and needs of the National Science Foundation, the Executive Office of the President, and the Congress. They include:

a) developing an improved knowledge base for S&T policy analysis;
b) summarizing the available knowledge and data relevant to specific issues;
c) conducting policy analyses and assessing policy options;
d) assisting in the assessment of S&T-related policy decisions;
e) enhancing the nation's science policy research and analysis capability in the research community.

II. SUMMARY OF RESEARCH TOPICS

Research proposals should address the following issues and problems.

A. SOCIOECONOMIC EFFECTS OF SCIENCE AND TECHNOLOGY

Proposals should be developed to a) identify and estimate the socioeconomic benefits and costs of S&T activities; b) assess the effects of government actions or policies[1] on socioeconomic outcomes from S&T activities; and c) identify and assess non-governmental factors that influence private and social benefits and costs from S&T activities.

Studies are encouraged on the following topics:

- Contributions of private and public investment in science and technology to national, sectoral, and regional economic performance;
- Distribution of economic costs of and returns from science and technology;
- Net benefits to society from technological innovation;
- Effects of science and technology on international transactions by the U.S. private sector;
- Effects of science and technology on individuals and social institutions.

B. INNOVATION PROCESSES AND THEIR MANAGEMENT

Proposals which identify leverage points[2] in the processes of technological innovation[3] are encouraged. These studies should aim to improve the formulation and assessment of federal policies that affect innovation processes in the U.S. and abroad.

---

[1] Examples of government actions or policies addressed by the research program of the Division include patent policy, tax incentives for R&D, regulation of the research process or the marketing of technologies, incentives for commercialization of inventions and/or technologies, economic regulation, environmental regulation, technology transfer incentives, standard setting, antitrust activity, and government funding of R&D.

[2] In the process of innovation, a leverage point is the point at which a relatively small change in strategy will produce a relatively large change in the rate and/or direction of innovative activity. This program is primarily concerned with those leverage points affected by public policy.

[3] Technological innovation is defined here as the set of activities ranging from the generation of an idea to its widespread use by society. The activities include the generation, research, development, transfer and diffusion of new and improved products, processes and services for public and private use.

Studies are encouraged on the following topics:

- Decisionmaking in the private sector leading to innovation;
- Decisionmaking in State and local government leading to innovation;
- Institutional roles and linkages in innovation processes;
- Federal civilian R&D management;
- Comparative studies of the effect of policies on innovation processes across industrial countries;
- The processes of transferring technology to developing countries;
- Role of entrepreneurs and small firms in technological innovation.

C. ENVIRONMENT, ENERGY AND RESOURCES

Proposals are encouraged to clarify the role of S&T in increasing the nation's capacity to adapt to changes in energy, environmental, and natural resource policies and conditions. The purpose is to contribute to an improved understanding of the ways in which the S&T knowledge base for Federal decisions and policies can be strengthened and better utilized.

Studies are encouraged on the following topics:

- Interactions among energy, resources, population, and environment;
- Economic and social effects of energy development activities;
- Alternative modes of Federal action related to environmental protection, and their secondary effects;
- Effects of environmental regulations on industry;
- Adequacy and utilization of the scientific and technical base for Federal environmental policies and regulatory actions.

D. TECHNOLOGY ASSESSMENT

Policy studies are encouraged which systematically define, explore, and evaluate direct and indirect economic, social, environmental, and institutional consequences of the introduction of a new technology into our society or of the expansion of an existing technology.[4]

---

[4] The Technology Assessment program, formerly part of the Directorate for Research Applications, is being transferred to the Division of Policy Research and Analysis. Additional information on the Technology Assessment program of studies may be obtained from Technology Assessment NSF 77-25, a Program Announcement of technology assessments in selected areas.

Proposals are encouraged in the following areas:

- Substantive technology assessments;
- Studies to develop and extend the methodological state of the art of technology assessments;
- Studies that enhance and promote the capability to utilize assessments.

E. SPECIAL PROJECTS

Funds are also available for projects which cut across the primary research areas described above as well as ideas from the research community which serve the Division's objectives but are not specifically discussed in this announcement.

III. DETAILED DESCRIPTION OF THE EXTRAMURAL RESEARCH TOPICS

This section provides background information on specific research topics of interest to the Division. It explains the research interests in some detail and provides a rationale for specific research questions. The discussion is designed to assist researchers in preparing proposals and to acquaint policymakers and others with the research and analysis activities of the Division.

A. SOCIOECONOMIC EFFECTS OF SCIENCE AND TECHNOLOGY

The objective of this program area is to make available for Federal decisionmaking 1) improved empirical information on the relationship of science and technology to economic performance and the quality of life, 2) improved information about the effects of government actions on the relationship, and 3) improved methods for generating such information. The relationship of science and technology to socioeconomic conditions is viewed from two perspectives: the influence of R&D and technological change on economic activity, and the changes in social welfare attributable to the science and technology process. Economic outcomes include productivity improvement, industrial development, regional economic growth, international competitiveness and foreign trade. Changes in social welfare include changed earnings of major participants in, or of those affected by, the innovation process; sharing of benefits and costs of new technologies among the producers, users, and the rest of society; modifications in the quality of products; and changes in life styles and the quality of working life.

1. THE CONTRIBUTION OF PRIVATE AND PUBLIC INVESTMENT IN SCIENCE AND TECHNOLOGY TO ECONOMIC PERFORMANCE

Investment in R&D and in the adoption of new technologies makes positive contributions to economic performance. The Federal government affects these contributions in two major ways: through actions that influence the outcomes of private sector R&D, and through direct Federal R&D funding.

The economic effects of Federal R&D spending (e.g., productivity improvements) and of Federal regulation are not completely known, partly because we have lacked adequate methods for assessing them. It would be useful to S&T policymakers to better understand how different kinds of R&D and rates of technology adoption are related to national economic performance.

General research questions include 1) What are the differential effects of privately and publicly-funded R&D on productivity change? 2) What is the relationship between the composition of R&D (e.g., divided into process and product R&D) and productivity change? 3) What are the causal relationships between output, market demand, profits, productivity, technology imported from other firms or industries, capital expenditures, and R&D spending? 4) What are the local and regional economic effects of R&D spending (especially public)? 5) What kind of evidence could be developed to distinguish among contributions to economic performance from various forms of government-funded R&D? 6) How can we measure the output of R&D, including the change in the quality of goods, processes and services?

Topics of particular interest to the program are outlined below.

a. Identification of the Economic Returns to Publicly-Funded R&D

There is conflicting evidence about the effects on economic growth and industrial productivity from government-funded R&D. Unanswered questions include: What is the importance of distinctions between kinds of government-funded R&D (e.g., basic vs. applied, differing funding mechanisms)? Do the characteristics of the industry and geographical region where R&D is performed systematically influence the economic effects of R&D?

Studies are needed to develop and empirically test models to address the following questions: 1) What are the effects on economic performance of government R&D expenditures? 2) When and how does the spillover from federally-procured R&D outputs (e.g., space-related) affect private sector productivity? 3) How do Federal R&D procurement practices affect the productivity of the firm, industry, or nation? 4) To what extent do Federal R&D dollars substitute for or complement private R&D dollars? 5) What are the different economic impacts of federally-funded R&D in different regions of the country?

b. Economic Effects from Differing Rates of Diffusion

It is often argued that the Government should intervene in the economy to speed the diffusion of techniques that would increase productivity, perhaps by setting up "productivity centers," by monitoring demonstrations, or in other ways.[1] But firms decide to adopt technologies for a variety of reasons, and the fastest possible diffusion may not be desirable. Could operational criteria be established to identify situations in which diffusion is either "too slow" or "too fast", i.e., in which public and private interests do not coincide? Are there specifiable conditions under which it would be possible to have operational criteria? What is needed is a conceptual model that would enable one to assess the benefits and costs of differential rates of diffusion of specific technologies.

---

[1] See for instance Manufacturing Technology--A Changing Challenge to Improved Productivity, A Report to the Congress by the Comptroller General of the United States, (Washington, D.C.: GPO, June 3, 1976).

2. DISTRIBUTION OF ECONOMIC COSTS AND RETURNS FROM SCIENCE AND TECHNOLOGY

Inability of a particular group (e.g., firms, inventors) to capture economic returns from its scientific or technological activity is one principal rationale used to justify government action to stimulate R&D. Exemption of a group (e.g., producing firms) from payment of costs to society resulting from technology (e.g., pollution, decreased safety) has been used to justify government action to regulate R&D processes and outputs. A major policy concern in the Federal government is that even with existing levels of Federal R&D support and regulation, the economy appears to be underinvesting in and misallocating resources for science and technology.[2] Measurement and assessment of external benefits or costs (i.e., uncompensated benefits or costs to individuals who are not parties to a transaction) and of the ability of private firms to capture returns from innovation would help resolve this issue.

Questions of continuing concern include: 1) What benefits do firms derive from the results of R&D performed in other firms for which they do not share the costs? 2) How do these external benefits vary by type of R&D effort or the kind of property right protection system used (e.g., patents, trade secrets)? 3) How important are risk and uncertainty in explaining divergences between social and private returns? 4) To what extent do divergences between social and private rates of return from innovation vary by market structure? 5) What are the benefits to innovating firms and to users from technologies which change the levels of external costs? How do these compare with the changes in external costs to non-users?

a. Development and Empirical Application of Approaches for Measuring and Analyzing Capturability of Returns

The prevailing view among economists is that industry underinvests in R&D for the following market failure reasons:[3] property right protection for many ideas and inventions is inadequate or non-existent, and the risk, uncertainty, and information problems are striking.[4] Understanding how and when these factors influence the distribution of returns from innovation helps in framing legislation on intellectual property rights and in deciding on government support for R&D. Recent work supported by the Division has improved our ability to identify the problems, and to measure the allocation of returns from individual innovations.[5] This work could serve as a basis for further empirical analysis.

---

[2] For example, see the April 27-29, 1976, Hearings on the Federal Research and Development Expenditures and the National Economy held by the Subcommittee on Domestic and International Scientific Planning and Analysis, Committee on Science and Technology, U.S. House of Representatives. Although policy makers in both the executive and legislative branches of the Federal Government may believe that under-investment is the case, no major policy changes are being envisaged. At this state of our knowledge, we do not know where underinvestment may be most serious, nor whether available policy instruments would raise net benefits to society.

[3] NSF 72-303 Research and Development and Economic Growth/Productivity.

[4] K.J. Arrow, "Economic Welfare and the Allocation of Resources for Invention," in The Rate and Direction of Inventive Activity. Ed. R.R. Nelson (Princeton: Princeton University Press, 1962), pp. 609-625.

One feasible way to determine the extent of underinvestment is to analyze social and private returns in situations which differ in any one of these respects: 1) the costs of claiming and enforcing property right protection; 2) the costs of obtaining information needed to produce or market technological ideas; 3) overcoming problems associated with technical risk and uncertainty.

Empirical research questions to be addressed include: 1) How do returns to firms that innovate compare with returns to firms that imitate? 2) How do different forms of intellectual property rights protection affect the returns to innovating firms? 3) Can major innovations that are covered by patents be easily infringed upon or imitated?

b. Distribution of Returns Among Employed Inventors and Firms

The adequacy of rewards to employed inventors has been a perennial controversy. Inventors must assign patent rights to their employer, and generally do not have employment contracts which link their rewards directly to the profits or royalties obtained from their inventions. Information about the effects of various contractual arrangements on the productivity and profitability of R&D would help public and private officials to determine which contractual relationships to encourage. Research questions include the following: 1) How do the direct economic rewards to the inventors of commercially successful innovations compare with rewards to less successful inventors in the same organization? 2) What have been the effects on company profits of alternative compensation programs for employed inventors?

3. NET BENEFITS TO SOCIETY FROM TECHNOLOGICAL INNOVATION

A central policy question is the influence of government policies and practices (e.g. taxes, regulation, antitrust) on the net benefits to society from technological innovation. Various governmental processes have been criticized for reducing social returns from R&D and technological innovation. Given the numerous other influences on innovation, no consensus is possible as to whether regulation or antitrust policies have, on the whole, been beneficial. As a result, studies to assess the influence of governmental policies and practices must focus on specific industries, types of technology, or types of government process.

---

[5] One study has stressed the high costs associated with claiming and enforcing property rights in ideas and inventions for different technologies in different types of firms (see S.N.S. Cheung, "Property Rights and Inventions: An Economic Inquiry," paper presented at the June 20-24, 1977, meeting of the Western Economic Association, Anaheim, California). Another study developed a method for measuring returns to society for a large class of innovations, and measured the associated returns to firms (see E. Mansfield, "Social and Private Rates of Return from Industrial Innovations," Quarterly Journal of Economics, May 1977).

There are several questions of continuing research interest. 1) What effects do alternative regulations of the applications of technology (e.g., for drug efficacy, product safety) have on the net benefits to society from science and technology? 2) What influences do different types of economic regulation (e.g., price and output regulation, antitrust) have on the net benefits society derives from innovation processes? 3) What are the benefits and costs to society resulting from alternative allocations of intellectual property rights for the outputs of private or government R&D? 4) What, if any, procedures can be developed to apply patent data as partial measures of the final outcomes of innovation processes?

a. The Effect of Government Regulatory Policies and Practices on Health Technologies

Development and testing of paradigms and methods to assess the influence of regulation on the social benefits from innovation processes requires examination of specific regulations and technologies. A cost-effective approach is to focus research efforts on a situation that satisfies the following conditions: presence of a set of regulations for a class of technologies; existence of a substantial data base for evaluation; availability of a good research base.

Such a situation exists for health-related technologies (e.g., drugs, medical devices and equipment, diagnostic techniques), an area of broad policy concern. Studies are needed to assess how government regulation of the research process and the marketing of new technologies affects outcomes from technological innovation. Although some studies have shown sizeable costs of government policies on health-related technologies, only preliminary assessments have been done on the net benefits from these policies to users and firms.[6]

The available evidence suggests the following research topics: measurement of the influence of regulation on outputs from health-related technological innovations; and measurement of the benefits and costs to society of alternative regulatory approaches. Research under the first topic could measure the benefits and costs of safety and efficacy regulation, where the benefits might be measured by the changes in the therapeutic values of new drugs or by estimates of the economic value of greater assurance of efficacy. For better measurements of the likely influence of future regulations, a study might develop benchmarks for the amounts, types, benefits and costs of medical devices marketed before new controls on their marketing go into effect.

---

[6] Studies funded by the National Science Foundation in this area have included: J.M. Jadlow, An Empirical Study of the Relationship between Market Structure and Innovation in Therapeutic Drug Markets, Oklahoma State University, 1976, NTIS #PB 263765/AS (final report); L. Lasagna, W.M. Wardell and R.W. Hansen, "Technological Innovation and Government Regulation of Pharmaceuticals in the United States and Great Britian," University of Rochester, in progress; H.G. Grabowski and J.M. Vernon, "The Effect of Product Quality Regulation on Innovation: The Case of the U.S. Ethical Pharmaceutical Industry," National Bureau of Economic Research, in progress.

b. Use of Patent Data to Measure Outputs of Innovation

Policymakers have a continuing interest in predicting industrial growth or decline. The increasing number of U.S. patents being granted to foreign nationals has led to concern that the inventiveness of U.S. firms may be declining, whereas foreign technological competition is increasing. Preliminary work has been done on the relationships among R&D spending, patenting activity, and international trade.[7] There has been an attempt to use patenting activity as an indicator of the "maturity" of a technology.[8]

Research questions include: 1) What is the relationship among patent counts, "maturity" of a technology, and economic factors, such as changing relative prices? 2) Are patent counts a reliable measure of the influence of technological change on the growth or decline of an industrial sector? 3) What information, if any, do foreign patent registrations provide about the changing international competitiveness of U.S. industry?

4. EFFECTS OF SCIENCE AND TECHNOLOGY ON U.S. PRIVATE SECTOR INTERNATIONAL TRANSACTIONS

The effects of private sector international technology transactions on U.S. welfare[9] are giving rise to questions about the necessity for government regulation. There is a serious concern about the effects of private sector international transactions on U.S. national interests, especially macroeconomic conditions such as employment, balance of trade, and productivity. Another concern is that U.S. firms may obtain inadequate returns, while foreign firms benefit excessively from international technology transfers. Government actions to stimulate U.S. private sector R&D have been proposed in order to maintain or advance international competitiveness. Some observers have claimed that foreign governments provide a better environment than the U.S. for new technology, and that this affects the ability of U.S. industry to compete.

These policy concerns raise a number of questions: 1) What are the effects of international technology transactions on U.S. employment, economic growth, and foreign trade? 2) What is the value of international technology flows for different industries and channels (e.g., exports, foreign direct investment, licensing)? 3) How complementary or substitutable are the various channels used by U.S. firms to transfer technology? 4) What effects do international technology transactions have on the technological output of U.S. and foreign firms? 5) How do technological innovations influence exports, foreign direct investment and licensing? 6) What is the effect of government regulations (U.S. and foreign) on the returns to U.S. firms from international technology transactions?

---

[7] D. Schiffel and C. Kitti, "Rate of Invention: International Patent Comparisons," Research Policy, forthcoming.

[8] Technology Assessment and Forecast 7th Report, Patent and Trademark Office, U.S. Department of Commerce, March 1977.

[9] A review of the state of knowledge appears in the National Science Foundation publication of papers and proceedings of a colloquium, The Effects of International Transfer on U.S. Economy, NSF 74-21 (Washington, D.C.: GPO, 1974).

a. Assessment of U.S. International Competitive Position

Assessment of how technology influences the international competitiveness of U.S. industry would help Federal officials address a number of policy issues. One issue is the extent to which the government should assist in the development of technologies. Another is the extent to which government should regulate international technology transactions.

The first step in this assessment is the development and testing of a method for estimating the competitiveness of individual industries. To develop and test a method, several questions should be addressed: 1) What types of international transactions are relevant to the policy issues? 2) What alternative environments determine the competition between U.S. and foreign firms in selling technology? 3) What is the contribution of imported technology to the competitiveness of U.S. firms?

b. Contribution of International Transactions to the Earnings of the Firm

Information about exporting and importing technology would help the government assess the private and social returns from international technology transactions. The measurement of returns involves assessing the costs of adapting and pricing of the technology. To make such an assessment, the following questions could be considered: 1) How can the price of technology be distinguished and compared under various types of licensing agreements (e.g., a sale/purchase of a patent, a cross licensing agreement)? 2) In terms of foreign investment, how can earnings on technology be separated from returns to capital? 3) What criteria do firms use in pricing technology for sale or purchase?

5. EFFECTS OF TECHNOLOGICAL CHANGE ON INDIVIDUALS AND SOCIAL INSTITUTIONS

Federal officials increasingly receive complaints from individuals and groups about the difficulties of adapting to the effects of technological change. Other complaints deal with the availability and characteristics of technologies. The way technology is introduced, applied, and regulated influences a wide array of work and consumer activities. In response to public concerns, government is increasingly (1) placing conditions on the introduction and use of technology and (2) instituting actions to help individuals adapt to and benefit from technological change. Studies in this area contribute to the development and implementation of public policies by providing information and analysis concerning the benefits, costs, and risks of S&T developments for individuals and various groups in society; the role of organizations and institutions (e.g., unions, businesses) in mediating the effects of technological change; the changes in the structure and functioning of organizations and institutions resulting from technological change; and the influence of individuals and social groups on the rate and direction of technological change.

In most cases, extramural studies provide this information and analysis by focusing on specific policy questions. Examples of such questions include: 1) How does technological change in the production and delivery of goods and services affect employment levels and the characteristics of jobs? 2) What factors influence the tradeoffs between regulation and information policies for handling technological risks in consumer and worker safety and health areas? 3) What are the costs and benefits of technological change in consumer products and services? 4) How does technological change affect the way individuals and groups use their time? 5) How does technological change affect the ability of disadvantaged individuals (e.g., educationally, economically, or physically disadvantaged) to engage in various productive activities? The first two questions (labor effects of scientific and technological developments and the policies for handling technological risk) will receive primary attention this year, and are discussed more fully in the following sections.

b. Implication of Scientific Information for Individuals and Organizations

Federal involvement in providing information and protection concerning the effects of new products and services is increasing. Development of policies requires better measurements of risks and better understanding of the factors which influence acceptability of risks. Of particular concern is the tendency of the public to disagree with policy makers and research experts as to what should constitute an acceptable or allowable risk. The research on risk analysis and risk taking is not integrated or analyzed in such a way as to help decisionmakers assess the tradeoffs between regulation and information policies.

Conceptual and empirical studies are needed to explore the factors (e.g., conditions of exposure and characteristics of the target populations) which influence the policy decisions regarding particular technologies. Information is particularly needed to assess regulatory and information policies regarding risks to workers (e.g., exposure to toxic substances) and risk to consumers or users (e.g., product safety). These two areas are of major and continuing concern to government.

a. Effects of Technological Change on Employment Opportunities and Conditions

To date, research and analysis of the effects of technological change on the level and characteristics of U.S. employment have focused on the aggregate situation. These figures do not reflect the employment changes in various industries and job categories. In order to develop policies dealing with worker adjustment to employment changes caused by technological change (e.g., policies concerning retraining of displaced workers), information of two types would be useful.

More evidence is required about the effects of technology-induced change on workers as categorized by demographic characteristics or by occupation and skills (e.g., semi-skilled, women, minorities, assemblers, operators).[10] This analysis is needed for three general types of technological change: technological development within the industry; technology-based changes in competition between industries; and international technology transactions and developments.

Determining the need for and possible forms of public mechanisms to help workers adjust to technological change (e.g., income security measures, retraining) requires assessment of the availability and effects of private mechanisms (those provided by the company or union).[11] Information on these private adjustment mechanisms is being improved by a current study. This study is developing and testing a model to estimate the economic and noneconomic outcomes of various types and mixtures of private adjustment mechanisms available to workers undergoing technological change within the plant or company. Further development of such measures is needed. Also needed is a conceptual and empirical analysis of the use of private mechanisms to handle employment changes resulting from technological development in other industries or from international technology transactions.

Policymakers are also concerned with the reverse side of the coin. They need to understand the effects of adjustment mechanisms and the collective bargaining process on the introduction and use of new technologies. One current study is making a preliminary analysis of the costs of adjustment mechanisms to the company. Another is analyzing the past relationships between collective bargaining procedures and the diffusion of technologies.[12] Additional empirical information and analysis is needed concerning these issues. Studies should pay particular attention to how the mixture of worker concerns for job or income security and the quality of working life influences and is influenced by new technologies.

---

[10] National Commission on Technology, Automation and Economic Progress. Technology and the American Economy (Report to the President and the Congress, 1966, 6 volumes). Washington, D.C.: U.S. Government Printing Office, 1966. F. Machlup. Effects of Innovation on Demand for and Earnings of Productive Factors. New York: New York University, 1975.

[11] Background work in this area may be found in L.M. Blair, Adjustment to Technological Change in the Labor Market Revisted. (Manpower Development Division, Oak Ridge Associated Universities, 1975), and in L.M. Blair, Mechanisms for Aiding Worker Adjustment to Technological Change: Conceptual Issues and Evidence, (Salt Lake City: University of Utah, 1975), available from NTIS: PB #237379/AS.

[12] D. McLaughlin, University of Michigan; A State of the Art Analysis Concerning the Effects of Labor Unions on the Rate and Direction of Technological Innovation. (Expected completion date: March 1979).

B. INNOVATION PROCESSES AND THEIR MANAGEMENT

For the purposes of this plan, the term technological innovation refers to the set of activities ranging from conception or generation of an idea to widespread use by society. Studies of innovation processes focus on the behavior over time of persons and institutions that engage in these activities. The knowledge derived from such studies is intended to help explain relationships between inputs to innovation--general economic conditions, specific federal policies, resources--and final outputs of innovation activity--productivity change, trade balances, employment rates, and the quality of life. Funds are available for studies of the factors and mechanisms that account for patterns in intermediate outcomes of the innovation process. These patterns include: rates and types of new ideas, level and composition of investment in innovation by public and private agencies, and the speed and pattern of the diffusion of innovations. The processes that link innovation inputs to outputs require validated explanations if public policies are to be directed toward appropriate leverage points and mechanisms.[1] The studies supported generally seek to identify and assess:

- Those who perform certain functions in the innovation process in specific industries or service areas (e.g., R&D, financing, technology transfer, acquisition, use, and evaluation);
- How the performers of these innovation functions relate to one another and what factors account for their behavior;
- How the functions of institutions such as government laboratories, R&D consortia, universities, and industry differ across product and service areas;
- What organizational arrangements and management procedures in Federal agencies are likely to result in strategies that effectively carry out innovation-related goals.

It has been firmly established that innovation processes vary considerably across industry,[2] economic sector,[3] and State and local government departments.[4] These differences suggest the futility of the search for a single theory or model of innovation. They imply that policy-relevant research on innovation processes should be limited to the behavior of individual organizations or groups of organizations at the industry or subindustry level.

---

[1] R. R. Nelson and S. G. Winter, "In Search of Useful Theory of Innovation," Research Policy 6 (1977) pp. 46ff.

[2] Nelson and Winter, op. cit.; G. Downs and L. Mohr, "Conceptual Issues in the Study of Innovation, "Administrative Science Quarterly, December 1976.

[3] M. Meyer and W. Williams. Comparison of Innovation in Public and Private Sectors; An Exploratory Study, University of California, Riverside. Report to the National Science Foundation, 1976.

[4] I. Feller, D. Menzel, and L. Kozak, The Diffusion of Innovation in Municipal Government. Final report to the National Science Foundation. Available from NTIS: Executive Summary, Document #PB 257068/AS; Final technical report, Document #PB 257069/AS.

The following topics represent the research priorities in this area.

1. DECISIONMAKING IN THE PRIVATE SECTOR LEADING TO INNOVATION

The rates of idea generation, investment in R&D, and diffusion of new technologies across and within industries differ according to the decisionmaking in individual firms. Process-oriented studies seek to explain these differences by investigating the factors that influence such decisions. Many of these factors are related to industry-wide or even national conditions (e.g., economic stability, public investment in education).

Public policymakers have recently shown concern for innovation-related problems in particular industries. They will probably sustain this interest. Accordingly, studies of decisionmaking should focus on those industries that are likely to attract the attention of Federal policymakers for one or more of the following reasons:

- o Low rates of productivity growth, capital investment, and stagnant or falling employment;
- o Rapidly rising costs of goods or services;
- o Labor-intensive or energy-intensive processes;
- o Low rates of technological change or low rates of investment in R&D;
- o Public need or demand in the foreseeable future.

For comparative purposes, the program will support a small number of studies of industries that exhibit high rates of technological change and productivity growth.

a. It is doubtful that any single study could examine all the factors that influence complex decisionmaking processes within the firm. Moreover, it is clear that the significance of individual factors will vary widely across industries and may even vary across firms. Knight, Kozmetsky, and Baca[5] suggest categories of factors that account for the level and composition of resources allocated to innovative activity. Empirical studies could focus on the conditions under which clusters of factors are significant for innovation in a particular firm or industry. Important factors and the policy instruments which may affect them include:

1) the use of productive resources, as affected by tax credits, patent rights, health and safety regulation;
2) the availability of capital, through loans, cost sharing, interest subsidies, cooperative ventures;

---

[5] K. E. Knight, and G. Kozmetsky, and H. R. Baca, Industry Views of the Role of the Federal Government in Industries Innovation. Graduate School of Business, University of Texas at Austin, January 1976. Final report to the NSF on grant No. DA-44364.

3) the structure and operation of markets, as affected by antitrust policies, trade policies and tariffs, regulation of product or service characteristics;
4) the informational aspects of R&D and innovation, influenced by demonstrations projects, regulation of advertising and other project information, government reporting requirements;
5) direct Federal expenditures through grants or contracts for R&D and demonstrations, direct government purchases, licensing of government-owned patents.

A study in this area could investigate how product regulations affect the adoption of existing innovations by potential users and the type of R&D investment made by suppliers of innovations. Are such regulations easy to "invent around," or do they block major paths of growth potential? Do they inhibit or stimulate certain types of research efforts? Can inferences be made about the costs and benefits of such regulations from data on changes in the rate and direction of research efforts?

b. Recent evidence suggests that the levels of both national and industrial investment in basic research have been declining over the past decade.[6] Little is known about the factors that influence investment by industries in basic research, so that the effectiveness of various direct and indirect strategies for encouraging investment in basic research remains uncertain. Studies could identify factors that account for investment in basic research by private firms and assess the sensitivity of these factors to changes in public policy. For example, studies are needed of the relationship between higher expenditures for basic research and diversification of commercial products. Studies could also explore whether types of basic research conducted in private firms differ from basic research conducted in academic settings.

c. The rate of innovation in an industrial sector is a function of technological opportunities as well as of the availability of resources and existence of appropriate incentives. The effectiveness of public policies intended to improve economic vitality via technological innovation obviously is a function of the technological opportunities available to industry. The analysis of proposed policies therefore requires a means of identifying and assessing technological opportunities at the industry level. Studies in this area could sharpen the concept and develop valid measures of technological opportunity. Subsequent studies could explore how various types of technological opportunities in different industries are linked to resource allocation decisions within the firms that comprise each industry.

---

[6] C. Kitti, "Alternative Incentives for Basic Research in Industry," unpublished staff paper, Division of Policy Research and Analysis, NSF, September 2, 1977.

2. DECISIONMAKING IN STATE AND LOCAL GOVERNMENT LEADING TO INNOVATION

Action by regional, state and local governments is essential if solutions to pressing domestic problems (e.g., transportation, housing, pollution abatement, law enforcement, education, energy conservation) are to be effected. Innovative activity, frequently initiated at the State or local level, is seen as one means of addressing these problems. To increase the availability of innovations that offer potential solutions, the Federal government invests a large proportion of its $8 billion civilian R&D budget in programs directed toward the problems of State and local government. The poor record of Federal efforts to promote the use of new technology in the non-Federal public sector suggests the need for empirical studies of decisionmaking processes in State and local government. Such studies, drawing on recent exploratory work, should focus on how State and local governments identify problems and set priorities. Studies could also explore sources and use of technical information and assistance, and strategies for successfully acquiring information, assistance, and political support. Although present studies focus on these factors in city agencies, comparable work on State agencies and legislative bodies is needed.

Public agencies operate in an institutional environment very different from that of private industry. The environment of public agencies is characterized by the nonmarket setting, accountability to a variety of extra-organizational groups, and lack of clear measures of performance. Conceptual and exploratory studies could address the following questions: How do these characteristics affect decision-making by State and local governments? What are their implications for Federal policy on technology transfer, technical assistance, and information dissemination?

3. INSTITUTIONAL ROLES AND LINKAGES IN INNOVATION PROCESSES

Reference was made earlier to variations in the institutional structures that exist across economic sectors and industries. For example, the agricultural and manufacturing sectors differ greatly in the types of organizations that support and perform R&D, test and evaluate products, perform demonstrations, provide technical assistance, and disseminate information. The nature of government and university involvement in the performance of these functions differs dramatically across industries. The importance to S&T policymaking of institutional analysis is discussed in recent works on innovation processes in private and public markets.[7] The research projects suggested below focus on particular institutions or industries that are of current concern to policymakers.

a. The Congress has noted recently that a strong national program in basic research depends upon linkages between industry and universities. There is concern that such linkages have weakened in recent years. Studies could explore the benefits of increased cooperation between basic research performers in universities and in the innovative industrial community. Drawing on available information, a study could assess the effectiveness of personnel exchanges, tax credits to encourage funding by industries of basic research at universities, and matching grants for long-term support of a cooperative research program between industry and a university.

---

[7] E. Wenk, Jr., and T. J. Kuehn, "Interinstitutional Networks in Technology Delivery Systems," in J. Haberer, ed., Science and Technology Policy (Lexington Books, 1977): J. D. Roessner, "Federal Policy and the Application of Technology to State and Local Government Problems," Policy Analysis (forthcoming); Nelson and Winter, Op. cit.

b. Considerable scientific and technical resources reside in governmental and quasi-government organizations such as Federal laboratories and Federal Funded Research and Development Centers (FFRDC's). In recent years, attention has been focused on increasing the benefits of public investment in these organizations by expanding their roles to include technical assistance to State and local governments and to the business community, especially small businesses. Considerable experience has accumulated over the years as Federal labs and FFRDC's have undertaken tasks for these new clients. There has been little systematic analysis of the effectiveness of these efforts, the problems encountered, or the interaction of the providers and recipients of technical assistance. Yet numerous demonstration and "seed money" projects have been supported to initiate action or establish the feasibility of expanded laboratory role. These projects have generated considerable data and experience that remains scattered and in various forms. Thus, studies in this area should draw upon existing case studies and available data to assess the consequences of current Federal personnel and procurement practices, agency missions and mandates, and R&D policies and organizational arrangements.

c. Many Federal agencies are charged with maximizing the application of the results of federally-financed R&D. These results may consist of research reports, ideas or techniques, or hardware in various stages of development. In some cases, commercial production is required for widespread adoption to occur (e.g., new energy-conserving appliances), in other cases it is not (e.g., computer programs for garbage truck routing). Development of strategies for making products, processes, or services resulting from Federal R&D available to users requires knowledge of the institutions involved in the transfer. Frequently these institutions are not directly concerned with R&D and innovation. They may include regulatory agencies, standards agencies, unions, educational and training bodies, and professional and trade associations. Studies could characterize the differences in institutional factors across industries and local government departments; identify the strengths, weaknesses, and roles played by the various participants in the processes; and relate these institutional features to dissemination and commercialization strategies in Federal agencies.

4. FEDERAL CIVILIAN R&D MANAGEMENT

The Federal Government can benefit from knowledge of improved ways to manage its innovation-related activities (e.g., R&D, product testing and evaluation, demonstration, technical assistance, and information dissemination). Two recently completed studies suggest that the management of Federal civilian R&D needs much improvement and that management techniques used successfully in private industry are not necessarily transferable to public agencies.[8] Moreover, there is concern that the investment in Federal civilian R&D is not sufficiently responsive to the problems faced by State and local government officials.[9] Some areas of interest to the program are:

a. R&D planning and project selection. How can the needs of prospective users of R&D products be identified, and the actual demand for innovation be estimated? How can this information be translated effectively into R&D agendas for Federal agencies? How effective are existing arrangements such as industry advisory groups and the "user needs committees" composed of State and local government representatives?

b. Conduct of R&D. Many types of institutional resources are involved in the innovation process. In the Federal R&D environment, the basic decision as to whether to perform R&D in-house, use a captive organization, academia, a nonprofit organization, or contract out to the profit-motivated sector (either small or large business) may significantly influence the success of Federal R&D programs.

c. Technology transfer and research utilization. Studies in this area could assess the conditions under which alternative information and technology dissemination strategies are likely to be effective. They could then explore ways of effectively implementing these strategies. Variations of the Cooperative Extension Service model need to be studied systematically and implications drawn for Federal practices. Present variations include the NSF/PTI Urban Technology System, remnants of the Department of Commerce's State Technical Services Program, the Energy Extension System, and State-supported or chartered technical assistance organizations such as the Pennsylvania Technical Assistance Program.

Federal agencies differ widely in the institutions they select to conduct R&D and the contractual arrangements they employ to implement their R&D programs. Studies in this general area could identify the conditions under which different choices of R&D performers and contract mechanisms lead to different R&D outcomes. The focus of such studies should be on Federal civilian agencies, though it may be useful for comparative purposes to review the experiences of the Department of Defense and NASA. Of particular interest would be a study of the consequences for R&D outcomes and technological innovation of "make-or-buy" decisions--the intramural versus extramural conduct of federally-funded R&D. Such studies could assist Federal managers in planning their R&D programs and could help policymakers develop management guidelines for more effective support and conduct of R&D.

---

[8] W.S. Baer, et.al., Analysis of Federal Funded Demonstration Projects: Final Report. Rand Corporation, R-1926-DOC, April 1976; P. House and D. Jones, Getting it Off the Shelf (Westview Press, 1977).

[9] PL 94-282, National Science and Technology Policy, Organization and Priorities Act of 1976.

5. COMPARATIVE STUDIES OF INNOVATION SUPPORT POLICIES ACROSS INDUSTRIAL COUNTRIES

Many industrial countries have adopted policies designed to stimulate new technologies, or to coordinate or support selected industries. The extent to which these policies have affected the development or adoption of new technology is unknown. There is continuing concern in the U. S. that such policies will result in increased technological competition for U. S. products, both in domestic and foreign markets. Additionally, questions concerning the adaptability of elements of these policies to U. S. conditions continue to arise. Previous studies have described these policies in various industrial countries.[10] Other studies suggest that innovation processes are much less affected by policies specifically designed to support innovation than by government activities such as tax policies and patent and antitrust legislation.[11]

6. TECHNOLOGY TRANSFER PROCESSES INVOLVING DEVELOPING COUNTRIES

To help the U. S. respond properly to less developed countries' (LDC) requests for greater and more appropriate transfers of technologies, a better understanding is needed of 1) the processes by which developing societies acquire and use science and technology, and 2) the processes by which U.S. organizations, both public and private, decide what science and technology to supply and what mechanisms to employ in the transfer. State-of-the-art reviews and assessments in the following areas will be given priority in FY 1978.

a. Innovation Processes in Developing Countries

Developing countries see the U.S. as a major source of science and technology which could help them solve many of their problems. In order to meet its objectives toward these countries, the U.S. has undertaken and proposed a variety of programs to assist them in using science-based knowledge, technical skills, and technology itself. In order to assess and improve the usefulness of these programs, a better understanding is needed of the processes by which technology is acquired, adapted and utilized by the developing countries. Studies could be undertaken that describe decisionmaking processes in LDC's regarding technological alternatives. These studies could explore how factors such as the scientific base, capital requirements, availability of skilled labor, social attitudes, market structures, government policy and practice, institutional characteristics and linkages, management techniques, and risk and cost considerations enter and influence the decisions.

---

[10] Department of Commerce, "Technology Enhancement Programs in Five Foreign Countries" COM-72-11412 mimeo, December 1972, J. H. Hollomon, T. J. Allen; National Support for Science and Technology: An Evaluation of Foreign Experiences" Center for Policy Alternatives, MIT, May 1976.

[11] Rubenstein, et al., Technical Innovation: R&D and Incentives, Westview Press, Boulder, Colorado, 1976.

Emphasis will also be placed on studies which examine the effects of institutional structures in developing countries on innovation processes. At present there is limited understanding of the characteristics of scientific and technological infrastructures which are appropriate for countries at different levels of economic and social development. As a result, neither developing countries nor development agencies have an analytical basis for determining the nature or size of programs that should be undertaken to enhance the contribution of S&T to national development. Work based on currently available knowledge and experience is needed to clarify the institutional characteristics of appropriate S&T infrastructures. This work would provide an analytic basis for the design of programs to enhance the contribution of U.S. science and technology to LDC's.

b. The Transfer of Technology from the U.S. to Developing Countries

The willingness and ability of U.S. private organizations to provide knowledge, skills and products may be unnecessarily inhibited by policies and practices of governments (U.S. and foreign). It is important to know the factors which affect their willingness and ability to supply LDC's. Studies in this area may focus on organizational decision processes: how U.S. organizations decide to supply technology and technical resources to developing countries (e.g., the availability of human and financial resources in the U.S. and LDC's, government policies, institutional characteristics and linkages, and information flows). For example, they might examine the risks inherent in overseas ventures; and how foreign incentives, regulations and requirements affect the ways in which private organizations make their products and expertise available.

The mechanisms by which technology flows require equal emphasis. Studies might address how multinational corporations affect the availability of technologies and skills appropriate for LDC needs. Studies might also address the role of U.S. universities in scientific and technological development in LDC's. Other studies might examine relationships between types of mechanisms used including recent trends and changes, and the nature of the technological resources being transferred.

7. ROLE OF ENTREPRENEURS AND SMALL FIRMS IN TECHNOLOGICAL INNOVATION

Studies could attempt to substantiate suggestions that small firms and individuals have economic and organizational advantages for innovations serving small, specialized, or local markets, and that, while there may sometimes be advantages of size in exploiting the fruits of R&D, the actual R&D itself is more efficiently done in small-to-medium size firms than in large firms.

A project could investigate the information and social contact networks that link technical entrepreneurs to sources of financing, paying attention to the costs of search and transactions and any uneven distribution of these costs by geographic region or field of technology. A project could also attempt to describe and assess the processes and criteria by which venture capitalists evaluate technology-based proposals.[12]

---

[12] A.S. Bean, D.D. Schiffel, M.E. Mogee, "The Venture Capital Market and Technological Innovation," Research Policy, Vol. IV, no. 4.

C. ENVIRONMENT, ENERGY AND RESOURCES

Historically, PRA has supported studies which examined technological choices for maintaining adequate energy supply, assuring environmental protection, and improving resource utilization. Additional activities have included support for and participation in interagency studies concerning food, nutrition, land use, and population. Reasons for pursuing work in these areas have included the high S&T content of the issue areas, NSF's mandate to provide broad support of science and technology, and the high public expectation of technological solutions. Such studies have provided a valuable base of information to Federal decisionmakers who determine national priorities and policies within these areas. During fiscal 1978 PRA will emphasize studies that assess the interactions among environmental, energy, population and resources issues, and the implications of these interactions for national policies. Additionally, a limited number of studies on topics of special interest will be initiated.

1. INTERACTIONS AMONG ENERGY, RESOURCES, POPULATION, AND ENVIRONMENT

The complexity and interrelatedness of the problems concerning energy, resources, population, and the environment make it very difficult for policymakers to address any single issue fully. Decisionmakers must consider the implications of present decisions, and what must be done now to understand problems that may not reach their full magnitude for decades. For example, urbanization of rural land combined with pressure from population growth and rising expectations mean that a decreasing amount of agricultural land must be cultivated more intensively. Energy-intensive agricultural practices (use of machinery and fossil-fuels) and heavy applications of pesticides and man-made fertilizer lead to problems of soil depletion and water and air pollution, and may result in social and economic disruption of rural society. Increased use of fertilizer could lead to stratospheric and climatic changes, which would in turn have disruptive effects on agriculture.

The development of energy resources (e.g., coal mining, oil drilling) and the siting of power generating facilities have a number of effects which may not be reflected in the prices paid by the users of the energy. These effects include environmental, demographic, and economic changes. For example, strip mining coal in one region may reduce the price for electricity paid by consumers in another region (if that electricity might otherwise be produced from oil plants), but the price charged to the consumer may not include the costs of land waste and pollution in the mining area.

Research in this area will be primarily directed at issue definition and at assisting policymakers in evaluating alternative techniques for addressing these critical problems and predicting the effects of alternative governmental actions. Research questions include: (1) What are the constraints on managing resource systems to produce optimal sustainable yields of renewable resources? (2) What are the institutional barriers to more efficient management, and how can they be overcome? (3) What are the impacts of alternative land use policies on local populations and resource bases (e.g., changes in water quality, soil erosion, atmospheric nitrate concentration, and the availability of water and land)?

2. ECONOMIC AND SOCIAL EFFECTS OF ENERGY DEVELOPMENT ACTIVITIES

Improved methods are needed for assessing energy supply options or alternatives with regard to the feasibility, possible payoffs if development is successful, costs of unsuccessful R&D efforts, timing for support of research and promotion of development, and potential for ultimate utilization in light of competitive alternative energy choices. This involves technical understanding of the alternatives, a comparison of their economic and social costs, and an analysis of international as well as national factors, "Alternatives" in their proper context are not tradeoffs just between one energy source and another (fusion vs. breeder, or fossil fuel vs. nuclear); they may also be tradeoffs among competing segments of the economy (biomass production for either energy or fuel vs. food production from the same land area, or use of water for agriculture vs. municipal supply vs. synthetic fuel production).

Unanticipated constrictions in energy and resource flows can cause significant economic and political upheaval since great shifts in price have little impact on immediate need and hence demand. Mass hardship may accompany a forced transition to new utilization patterns, whether or not there is an eventual reversion to traditional cost-price-supply-demand relationships. Society needs to be sufficiently informed about the consequences of such changes in energy and resource flows to protect itself adequately in advance. This calls for knowledge of the international energy and resource situation in relation to national needs, knowledge of the alternatives available to deal with various contingencies, and a public sufficiently informed through dissemination of that information to have the ability and the willingness to make timely decisions. Information is also needed about the flexibility and resiliency of systems affected by such constrictions in energy and resource flows.

3. ALTERNATIVE MODES OF FEDERAL ACTION RELATED TO ENVIRONMENTAL PROTECTION AND THEIR SECONDARY EFFECTS

A major public policy concern is the effectiveness of various modes of Federal intervention. This concern is increasing as more environmental legislation is enacted and implemented, and as more individuals and institutions are affected by multiple statutory and administrative requirements. What are the costs of environmental regulations or policy alternatives to the consumer, a municipality, an industry, or the economy as a whole? What are the incremental costs and benefits of moving from one level of environmental regulation to another? In achieving one environmental objective, are there negative effects on other societal or environmental objectives (e.g., an air quality problem or high energy cost resulting from incineration of solid wastes, or an increase in solid residuals for disposal in land or water caused by regulations on incinerator air emissions)? How well are these impacts understood? How can S&T information be used to attain balanced solutions to a large number of individually worthwhile, but competing, objectives? What flexibilities can be built into environmental strategies to allow for changes in knowledge as S&T uncertainties are reduced? These broad issues could be addressed in general and for specific environmental problems and programs.

4. EFFECTS OF ENVIRONMENTAL REGULATIONS ON INDUSTRY

The two issues of principal interests are: (1) What are the impacts of environmental regulations on industry - e.g., on technological innovation; economic costs to the industry and to the consumer; site relocation; and the degree of correction of the environmental problem? (2) Are the differences in industrial responses influenced primarily by the characteristics of the firm or industrial process being regulated, the specific nature of the environmental regulation and its enforcement, the type and extent of the environmental hazard, or other factors?

Previous work on these issues has revealed many theoretical and methodological problems in obtaining valid and useful results. Effort in FY 1978 will be devoted to evaluating earlier work and to preparing guidance for future researchers on the types of questions to be addressed and on appropriate methodologies. PRA will review problems encountered in past studies that future projects should seek to overcome. The Division will also outline ways Federal agencies can participate more effectively in the studies.

5. ADEQUACY AND UTILIZATION OF THE SCIENTIFIC AND TECHNICAL BASE FOR FEDERAL ENVIRONMENTAL POLICIES AND REGULATORY ACTIONS

A problem receiving increasing attention within government and the scientific community is that the perceived or actual magnitude of an environmental problem may be sufficient to call for immediate government response in the form of a policy, regulation or law, even in the absence of documented and validated information necessary to support an informed decision. Such information might include data on the perceived and actual nature and severity of the problem, approaches that would be effective in mitigating or eliminating the problem, and the related costs and social and environmental effects of such approaches.

There are many obstacles to obtaining such information, however. Occasionally, environmental effects are acute and immediately obvious but more often they are subtle, long-term, and hard to detect. Data are difficult and expensive to gather, and difficult to interpret. Various environmental effects are interactive; amelioration in one area may create or exacerbate a problem in another. Environmental considerations become more complex as modern industrial society generates greater impacts on the quality of the human and physical environment; as improved knowledge leads to recognition of a greater number of potentially serious problems; and as public awareness increases and demands better solutions.

Public policy concerns of particular interest are:

- How can the S&T knowledge base be upgraded and more effectively used in decisionmaking?
- Are Federal research programs supportive of the information needs of the regulatory process? What is the appropriate balance between research directed at specific and immediate regulatory needs and longer-term research directed at predicting and understanding future hazards?
- What does judicial experience reveal about the quality of S&T information used in policymaking and regulatory decisionmaking?
- Would the development of environmental significance thresholds for various pollution media and for different categories of proposed Federal actions improve the quality of environmental impact statements?

Of particular interest to PRA during FY 1978 is an analysis of the quality and utilization of environmental impact statements. The National Environmental Policy Act of 1969 (NEPA, P.L. 91-190) requires the preparation of an environmental impact statement (EIS) to accompany "...every recommendation...on proposals for...major Federal actions significantly affecting the quality of the human environment...". This requirement was intended to internalize concern for the environment within the routine decisionmaking processes of the Federal Government. An analysis of recent experience[1] suggests, however, that the EIS preparation and review processes may need overhauling. At the June 1977 Council on Environmental Quality public hearings on NEPA and EIS reform, critics agreed that EISs tend to be too long, detailed, and laden with jargon. They are also overly broad in coverage of insignificant or peripheral issues, while deficient in coverage of critical impacts on the environment. Critics of the EIS process further allege that most EISs are substantively weak; that environmental conflicts are resolved through the judicial system on the basis of procedural compliance with applicable statutes and regulations, rather than on the basis of their substantive merits; and that even well-prepared, scientifically credible EISs do not significantly affect decisionmaking on major public policy issues affecting the environment.

---

[1] See, for example, Council on Environmental Quality, Environmental Impact Statements: An Analysis of Six Years' Experience by Seventy Federal Agencies (March 1976) and various papers presented at June 1977 CEQ hearings on environmental impact statement reform pursuant to Executive Order 11991, "Relating to Protection and Enhancement of Environmental Quality" (May 24, 1977).

In FY 1978, PRA plans to examine and evaluate these criticisms. This effort will combine intramural work with invited extramural planning papers to provide the format and agenda for a PRA-sponsored conference on "Substantive Adequacy of EISs." At this conference, NEPA scholars, discipline specialists, and private and public decisionmakers will discuss state-of-the-art techniques for identifying and assessing environmental significance thresholds and will define researchable issues and research priorities. The conference output will be an assessment of research needs and priorities for extramural studies over the next few years, with emphasis on the specification of extramural studies examining the development and potential use of environmental significance thresholds in public policy decisionmaking.

IV. PROGRAM GUIDELINES AND PROCEDURES

A. PROGRAM POLICIES

The extramural research program is closely related to and coordinated with a program of intramural staff research and policy analysis, including staff consultation with other Executive Branch offices and participation in interagency task forces and committees, conferences and seminars. The majority of research supported by the Division results from unsolicited proposals submitted in the areas outlined in this announcement. Where appropriate, Program Solicitations or Requests for Proposals are developed and made available to the research community. The Division also provides support for longer term policy research through its Programmatic Support awards. Information on these awards may be obtained by writing to the Division for copies of its Programmatic Support Solicitation.

Types of Projects Supported

Extramural projects supported by the Division may be empirical investigations involving collection of new data; analysis of existing data; feasibility studies; state-of-the-art reviews and assessments; development and testing of models and measurement techniques; and evaluations. Workshops, conferences or seminars are supported in some cases, where the issues to be addressed are well defined and the workshop is necessary to accomplish some element of the research program. The outputs from such workshops or conferences should be specifically designed for some policymaking group, and the results should be made publicly available. Evaluation studies may focus on specific projects or programs supported by PRA or other agencies, and are concerned with determining their scientific and analytical quality, potential usefulness to policymakers, and impacts on the user community.

Eligibility

Program participation is open to academic institutions, to units of government (Federal, State, regional, or local), to nonacademic, nonprofit or profit organizations, or to a combination of any such institutions or organizations. Awards to individuals are rare but are not precluded. Those contemplating a request for support without organizational affiliation should make this clear at the earliest opportunity.

Types of Awards

An award resulting from the submission of an unsolicited proposal may take the form of a grant, contract, or other arrangement. The type of award instrument will be determined by the National Science Foundation and, when necessary, will be based on negotiations with the prospective awardee. The type of instrument will depend upon the nature of the work to be done and the terms of performance. Cost sharing will be required for awards resulting from unsolicited research proposals. Proposals submitted as a result of this announcement are considered unsolicited. (See page 30 for cost sharing explanations).

Notification of Award

Notification of an award is made by a formal award document signed by the NSF Grants Officer or Contracts Officer. The award period begins on the effective date specified in the award document and continues until the expiration date stated therein. Expenditures incurred prior to the effective date of the award may not be charged to the NSF award.

B. PROPOSAL DEVELOPMENT AND SUBMISSION

Letters of Interest

As a first stage in the proposal process, proposers should submit a letter which summarizes the policy issues and the research question(s) or hypotheses the study intends to address, the research approach or study design to be used, the contribution which the project hopes to make, and the intended participants. In the case of empirical studies, a brief discussion of the data needs and available resources should be included. These letters will be reviewed to determine whether the proposed work is consistent with program objectives and priorities. Applicants are encouraged to discuss with the PRA staff the research concepts, methodology, and possibilities for cooperation with other research groups or government programs having related interests before developing a preliminary proposal. These letters should be sent to the Division of Policy Research and Analysis, National Science Foundation, 1800 G Street, N.W., Washington, D.C. 20550.

Preliminary Proposals

After the letter of interest is reviewed, five copies of a preliminary proposal should be submitted to the Division for internal staff review. These preliminary proposals should include all the components of a final proposal. However, they should not be signed by officials of the proposing institution(s) and should be clearly marked as a preliminary proposal. The preliminary proposals should also be sent directly to the Division of Policy Research and Analysis offices.

Final Proposal

Twenty copies of the formal final proposal, bearing official signatures, should be sent directly to:

Central Processing Section
National Science Foundation
Washington, D. C. 20550

ATTN: Division of Policy Research and Analysis

Target Dates

Formal proposals may be submitted at any time during the year, but should be submitted as early as possible to assure adequate time for review and processing. Approximately 4 to 6 months should be allowed for review and decision following the receipt by NSF of a formal proposal. Therefore, quarterly target deadlines for final proposals are as follows:

Target Funding Date	Formal Proposal Due By
Jan. 1	Sept. 1
April 1	Dec. 1
July 1	Mar. 1
Oct. 1	June 1

Proposal Format and Content

Proposals should cover the items listed below in 35 double-spaced pages or less. The proposal should be direct, concise, and informative. All items should be covered in the order shown. The space allocated to each will depend upon the problem chosen and the principal investigator's approach. Attachments should be used only when extensive background material would be helpful to the reviewers.

1. Cover Sheet--See Appendix A for format.
2. Abstract--of not more than one page. Include identification of the problem and a summary of the approach, project objectives, anticipated results, and implications of the project results.
3. Identification and Significance of the Problem Area--A discussion of the specific problem(s) being addressed and its importance.
4. Objective of Study--A discussion of the contribution the study will make to the particular area of science and technology policy. The type and significance of the project's output should be included.
5. Research and Analysis Plan--Should include a discussion of the conceptual framework or model to be used, the specific hypotheses or research questions, the literature and/or data to be used in the project, and the data collection and analysis plans, if applicable to the project. The discussion should also include the procedures to be used to insure objectivity and balance in the project.
6. Related Studies--Describe significant related studies conducted by members of the project staff or by others, and discuss any planned coordination with other work in the field.
7. Final Report--acknowledgement that 100 copies of the final project report and 200 copies of the executive summary will be provided to PRA not more than thirty days following the end of the award period. The proposal should acknowledge that the final report will be evaluated according to the regular PRA guidelines. (See page 36) Plans for dissemination of project output should also be discussed.
8. Project Personnel and Bibliography of Directly Related Work--Brief curricula vitae for the professional staff, summarizing education, related experience, and bibliographic information related to the proposed work.

9. Institutional Qualifications--Should cover the resources available at and the relevant experience of the institution. Resources include personnel, computer and library facilities, and ties to both sources of data and potential users of the results.
10. Project Management Plan--Should include the time and cost schedule for the proposed work and the time allocations and responsibilities for the project staff members. It should also discuss the progress reports that will generally be provided to the PRA monitor on a quarterly basis.
11. Current Support and Pending Applications--Each proposal must list all research, in addition to the proposed project, to which the senior research personnel have committed a portion of their time for the period of time covered by the proposal. This information should include titles and dates of current grants or contracts, source of funds, annual budget levels, and the person-months committed in each case. The proposal must also provide analogous information for proposed research which is being considered by or will be submitted to other possible sponsors including other NSF programs.
12. Budget--The proposal budget should be prepared in the format presented in Appendix B. Where the total cost of the proposed effort is expected to exceed the budget requested from NSF, proposers must indicate the sources from which additional funds are committed and the amounts of those funds.

Cost Sharing

The budget should summarize the estimated total project cost which is being requested from NSF after deducting the share which the applicant institution or organization plans to contribute to such costs. The legislation providing funds to the National Science Foundation and other independent agencies requires cost sharing by recipients of awards resulting from unsolicited research proposals. Cost sharing does not apply to proposals submitted solely for the purpose of supporting conferences, workshops, etc. This provision for cost sharing requires that the Foundation pay less than full costs of research projects performed under awards resulting from unsolicited research proposals. The degree of cost-sharing is based on factors such as the organization's interest in the project and the potential benefits it will receive. Cost sharing, however, must be more than one percent of total project costs. Cost-sharing amounts should be explained in the proposal and in the footnotes to the budgets, particularly where non-academic organizations are involved. Cost sharing should be shown separately from the line item amounts requested from NSF so that the cost sharing, when added to the amount requested from NSF, will equal the total project costs. The amount of cost sharing is determined in negotiations between NSF and the performing organization in accordance with the guidelines contained in Federal Management Circular (FMC) 73-3.

Allowable Costs

The NSF Grant Policy Manual, NSF 77-47, Chapter V, may be consulted for general guidance as to allowable costs which may be included in the proposed budget. Following are some of the instructions that are especially applicable:

a. Salaries and Wages. This entry should include only direct labor costs. Anticipated consultant fees should be shown under the category "Other Direct Costs." Except for data considered to be "priviledged information" (see following section), the proposal (including the proposed budget) may be made available to outside advisers and reviewers. The budget must include the names of all senior personnel, an estimate of the amount of effort which they will devote to the project (expressed in person-months or fractions thereof), and the dollar estimate of the total direct labor costs to the project of such senior personnel. For other categories of personnel, names may be omitted but numbers and costs must be shown together with person-month estimates for other professional personnel.

The submitting institution may request that senior personnel salary data not be released to persons outside the government. In this case, the item for senior personnel salaries in the formal proposal may be expressed as a single figure and the person-months represented by that amount omitted. If this option is exercised however, senior personnel salaries and person-months must be itemized in a separate statement, two copies of which should accompany the proposal. This statement must include all of the information requested above for each person involved.

b. Permanent Equipment. In general, funds will not be provided for purchase of permanent (capital) equipment, including computers.

c. Travel. The type and extent of travel and its relationship to the project should be specified in the proposal. Allowances for air travel will not normally exceed round trip jet economy air rates. Requests for support of subsistence costs or per diem allowances must be consistent with the policies of the proposing institution. If foreign travel is contemplated, the points of origin and destination for each trip should be specified.

d. Publication Costs. Cost of preparing, publishing, and disseminating the results of research conducted under the award, including costs of reports, reprints, manuals, handbooks, page charges, or proceedings and other journal costs, and necessary illustrations should be included.

e. Computer Costs. Computer charges should include average rate/hour, number of hours to be used, and type of computer, and the relationship to the project should be briefly explained.

f. Other Direct Costs. Any other anticipated direct costs not included above should be itemized, for example, space rental, information service charges, consultant compensation. Consultant compensation rates should show separate amounts for (1) actual services and (2) for each additional component of the rate, if any, (e.g., travel, secretarial support). Payment for consultant services may not exceed a rate of $183 per day.

To the extent that consultants are to be used, the need should be justified and information should be provided on the individual's areas of expertise, their primary organizational affiliation, daily rate, and number of days each is expected to be used.

None of the research or substantive effort under an NSF grant may be subcontracted or otherwise transferred to another organization without prior written approval from the NSF Grants and Contracts Officer. If major tasks are to be subcontracted or shared, the associated organizations and the specific tasks should be identified, and arrangements for supervision explained. If a subcontractor has been identified, the proposal should explain the basis for selection of the organization, the extent of competition or consideration given to others, the work to be performed, and the reasonableness of the cost. A proposed performance statement and budget should be included. Subcontracts planned to be awarded to small businesses should be identified.

g. Indirect Costs. Awards will provide reimbursement for indirect costs in accordance with current NSF policy contained in Section GPM 530 "Indirect Costs," of NSF 77-47.

Privileged Information

Since the proposal is considered an integral part of the award instrument, proposals resulting in awards will normally be made available to the public upon proper request under the Public Information Act of 1966 as amended (5 USC 552). However, trade secrets and business information such as salaries of key personnel will be treated in confidence if this information is prepared in a separate statement rather than in the text of the proposal or in the budget itself. Two copies of these separate sheets or salary schedules should be attached to the original proposal only and should contain a legend similar to the following: "It is requested that the following (specify business information, salary schedule, or trade secret) not be released to persons outside the Government." These separate sheets must be signed by the official who endorses the proposal. Without assuming any liability for inadvertent disclosure, NSF will seek to limit dissemination of such information to its employees and, where necessary for evaluation of the proposal, to outside reviewers. In any case, NSF will not be limited in using similar information obtained without restriction from another source.

A proposal that does not result in an award may be retained by the Foundation. Such a proposal will be released only: (1) with the consent of the proposer; or (2) to the extent required by law. A proposal may be withdrawn at any time prior to final action thereon by the Foundation.

First-Time Applicants

In the event that the submitting organization has not recently been the recipient of an NSF award, it is recommended that appropriate administrative officials be familiar with the NSF policies and procedures contained in the NSF *Grant Policy Manual* (NSF 77-47), which are applicable to most NSF awards. The Government Printing Office provides subscription service for the *Manual* to assure that users will have the latest, up-to-date information. The subscription price is $12 per *Manual* for domestic customers and $15 for foreign.

Subscribers will automatically receive subsequent updating supplements without additional charge. Copies of the Manual have been distributed to all NSF grantees. Other organizations or individuals seeking subscriptions may order them directly from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

If the submitting organization has not already done so, it should be prepared to furnish the following to the NSF Division of Grants and Contracts on request:

- Basic information regarding organization and management, as outlined in Section GPM 340, Prospective Grantee Organization and Management Data, of the Manual, with particular reference to the most recent certified financial management statement required of nonacademic organizations.

- An assurance of compliance with the NSF regulation under Title VI of the Civil Rights Act of 1964, as outlined in Section GPM 700, Civil Rights Act of 1964, of the Manual.

- Identification of the cognizant federal negotiating agency which has approved the organization's indirect cost base and rate(s) and the date of the most recent negotiation. If the submitting organization does not have a federally-approved indirect cost base and rate(s) the business officer should be prepared to submit an indirect cost proposal, as outlined in Section GPM 201d of the Manual, when requested to do so. Contents and financial data included in indirect cost proposals vary according to the nature of the proposing organization. Appropriate guidelines for your organization may be obtained by writing the Policy and Cost Analysis Branch, Division of Grants and Contracts, Room 206, 1800 G Street, N.W., Washington, D.C. 20550, or calling (202) 634-7545.

Small Business Applicants

Profit organizations should complete the following declaration regarding small business on the cover sheet:

"This organization [] is, [] is not, a small business concern."

A small business concern for the purpose of government awards is a concern, including its affiliates, which is independently owned and operated, is not dominant in the field of operation in which it is contracting, and, for research and study proposals, has fewer than 500 employees. See Code of Federal Regulations, Title 13, Part 121, as amended, which contains detailed definitions and related procedures.

C. PROPOSAL EVALUATION

Procedures

Formal proposals are reviewed by substantive experts and potential users in universities, nonprofit and profit organizations, State and local governments, and Federal organizations. Related proposals will be reviewed together where feasible, so that they may be compared and priorities among them established.

Additional review of proposals is provided by the respective program officer, the Division Director, and the Assistant Director of the Directorate for Scientific, Technological, and International Affairs.

The principal investigator or project manager is advised of the decision on the proposal and is provided a summary of reviewer comments. Verbatim reviewer comments (without attribution) will be provided to the principal investigator or project manager upon written request. A summary of the results of the review process is also transmitted to the reviewers after a decision has been reached by the Foundation.

Criteria for Evaluation

Proposals will be evaluated according to the following criteria:

- Significance of the proposed research and analysis for science and technology policymaking, with particular focus on the magnitude of the likely contribution of knowledge and the importance of the problem area.
- Quality of the proposed study design, including the extent to which the proposal reflects knowledge of related research, and adequacy of the research designs and methods for the problem area.
- Quality and appropriateness of the analysis plan.
- Adequacy of procedures and ability of the project staff to conduct the proposed research with objectivity and balance, including consideration of non-NSF sources of funding.
- Adequacy of the project management plan.
- Qualifications of the project staff, including training or experience in related areas of research.
- Capabilities of the institution, particularly the availability of library and data resources, availability of complementary staff resources and consultants, and the ties to potential users of the project output.

Reviewers are asked to provide comments and ratings on each of these features. Additionally, reviewers are requested to indicate their overall evaluation and their recommendations regarding funding. Final funding decisions are the responsibility of NSF, and are based on reviewer ratings, reviewer comments, and the internal NSF proposal evaluation procedures described above.

During the review process, some proposers may be asked to clarify particular points in their proposal. However, NSF reserves the right to make an award decision on the basis of the initial submission without further discussion.

D. REPORTS AND PUBLICATIONS

Reports on results and findings as well as reports on project progress are required. Specific requirements for progress reports will be negotiated between the proposer and the NSF program staff, and will be included in the formal proposal and the award instrument. Generally, the requirement will be for quarterly progress reports.

Within thirty (30) days of the end of the award period, 100 copies of the final project report and 200 copies of the executive summary should be submitted to the Division offices for evaluation and dissemination. In addition, within ninety days after the expiration of an award, two copies of the final project report and two copies of the Summary of Completed Project (NSF Form 98A-Appendix C) must be submitted to: Division of Grants and Contracts, Post Award Projects Branch, National Science Foundation, Washington, D. C. 20550. All reports must carry an acknowledgement statement on the cover page such as the following: "This material is based upon work supported by the National Science Foundation under grant/contract #_________. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation."

All final project reports and executive summaries will be submitted to the National Technical Information Service (NTIS) of the Department of Commerce to insure public availability of all PRA extramural research products. Additional arrangements for publishing are encouraged and should be discussed with the NSF staff.

In an effort to provide for the widest practicable and appropriate dissemination of the research results from PRA-supported projects, reports, books, monographs, films, computer programs or other publishable materials developed under a PRA award may not be copyrighted or contain any printed restrictions concerning reproduction or use unless specifically provided for by the award or authorized in writing by NSF. This, however, is not intended to preclude the publishing of articles in copyrighted scientific or professional journals, or the publishing of books based on NSF-supported research, when permission for copyright is obtained from the Grants and Contracts Officer.

Requests for permission to copyright should explain how copyright, rather than placing the material in public domain, will enhance dissemination and should set forth a proposed publication plan. If copyright is authorized by NSF and commercial publication is to be undertaken, NSF may require review of the publisher selection procedures, the publication agreement, and control over the disposition of income or royalties.

All materials, whether or not copyrighted, shall be subject to a royalty-free, irrevocable, worldwide, nonexclusive license by the United States Government to reproduce, perform, translate, and otherwise use and to authorize others to use such materials for government purposes. In addition, the Government reserves the right to reproduce and sell the materials through the

National Technical Information Service (NTIS), the Government Printing Office (GPO) or other sources. In some instances, in order to obtain distribution, NSF may be willing to accept a more limited arrangement.

If extracts of copyrighted materials, such as journal reprints or published illustrations, are to be included in a report or other materials, prior permission should be obtained from the copyright holder(s) and notice of such permission included in the report or materials.

Copies of noncopyrighted reports, publications, or materials produced with NSF support may be sold; however, such sales should be on a nonprofit basis. Therefore, sales prices should be established so that no more than reasonable publication and distribution costs not otherwise reimbursed will be recovered.

Commercial publication or distribution of copyrighted reports or materials may be undertaken only with the prior written approval of the Division of Grants and Contracts.

Dissemination and discussion of project output by a variety of channels (e.g., scholarly publications, professional society meetings) is encouraged. Where appropriate, researcher participation in the utilization of the project output by policymakers will be encouraged and supported.

Evaluation of Project Output

All final reports resulting from extramural policy studies and research awards will receive some form of evaluation concerning the project methods, findings, and implications. These evaluations may be accomplished by a variety of means, both extramural and intramural. Such means include: mail peer review of reports, staff reviews, panel reviews, commissioned discussion papers, and colloquia or conferences. Choice of the specific means of review will be based on the ability to provide a timely and meaningful evaluation, reasonable economy in the use of resources, and relevance to the interests and perspectives of intended users.

Evaluation procedures for a specific project will be discussed with the principal investigator, with the final decision being made by the Foundation staff. Funds for the evaluation may be included in the original proposal or provided later, depending on the evaluation format to be used.

Evaluations of project output where public policy alternatives are formulated, assessed, or recommended will generally be made publicly available with the final report through NTIS. In these cases, a response to the evaluation by the project staff will be allowed.

Formative evaluations are also used during the course of the extramural projects, including staff evaluations of specific aspects of the project and reviews of interim or draft final reports by potential users and others. Such evaluations seek to provide suggestions concerning the development of the project and to enhance the quality and usefulness of the final report.

E. PROJECT MONITORING AND ADMINISTRATION

Management practices and fiscal matters concerned with the awards will be monitored by the Division of Grants and Contracts of the NSF. Technical monitoring will be the responsibility of the PRA staff. Procedures and policies for administration of NSF grants are contained within the NSF Grant Policy Manual, October 1977. Copies of this manual may be available at the business office of the university or research organization, or may be obtained from the U.S. Government Printing Office (document NSF 77-47).

APPENDIX A

RESEARCH PROPOSAL SUBMITTED TO THE NATIONAL SCIENCE FOUNDATION DIVISION OF POLICY RESEARCH AND ANALYSIS

By

Institution and
Mailing Address

Title of Research Project

Proposed Starting Date ____________________ Amount Requested ______________ Proposed Duration in Months ________________

Principal Investigator:	Co-Principal Investigator(s) or Project Manager (if different from P.I.):
Name ____________________	____________________
Title ____________________	____________________
Social Security No. ____________	____________________
Department ______________	____________________

Endorsements:

	Principal Investigator	Department or Program Head	Institutional Administration Official
Name	____________	____________	____________
Signature	____________	____________	____________
Title	____________	____________	____________
Telephone No.	____________	____________	____________
Date	____________	____________	____________

(provide same information for additional co-principal investigators here)

* Submission of social security account numbers is voluntary, and refusal to disclose a social security number will not affect an institution's eligibility for an award. Social security numbers are used by the Foundation to monitor and facilitate the receipt and processing of numerous proposals, as well as to maintain data on actions taken. The number is solicited pursuant to the general authority of the Foundation under the National Science Foundation Act of 1950, as amended.

SUMMARY
PROPOSAL BUDGET

ORGANIZATION AND ADDRESS	**FOR NSF USE ONLY** PROPOSAL NO.
	DURATION (MONTHS)
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	PROPOSED | REVISED

NSF USE	A. SENIOR PERSONNEL (LIST BY NAME; SHOW NUMBERS OF PEOPLE IN BRACKETS; SALARY AMOUNTS MAY BE LISTED ON SEPARATE SCHEDULE) GPM 205.1b	NSF FUNDED MAN MONTHS CAL.	ACAD	SUMR.	FUNDS REQUESTED BY PROPOSER	FUNDS GRANTED BY NSF (IF DIFFERENT)
	1. P.I./P.D.				$	$
	2. CO P.I./P.D.				$	$
	3. CO P.I./P.D.				$	$
	4. CO P.I./P.D.				$	$
	5. CO P.I./P.D.				$	$
11115	6. ( ) ◄—— SUBTOTALS A1 - A5 ——►				$	$
	FACULTY AND OTHER SENIOR ASSOCIATES (ATTACH EXTRA SHEET IF NECESSARY)					
	7.				$	$
	8.				$	$
	9.				$	$
	10.				$	$
	11.				$	$
11117	12. ( ) ◄—— SUBTOTALS A7 - A11 ——►				$	$
	B. OTHER PERSONNEL (LIST NUMBERS IN BRACKETS)					
11141	1. ( ) POSTDOCTORAL ASSOCIATES				$	$
11149	2. ( ) OTHER PROFESSIONALS				$	$
11150	3. ( ) GRADUATE STUDENTS				$	$
11152	4. ( ) UNDERGRADUATE STUDENTS				$	$
11182	5. ( ) SECRETARIAL - CLERICAL				$	$
11183	6. ( ) TECHNICAL, SHOP, OTHER				$	$
	TOTAL SALARIES AND WAGES (A+B)				$	$
11200	**C. FRINGE BENEFITS** (IF CHARGED AS DIRECT COSTS)				$	$
	TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$	$
	D. EQUIPMENT (LIST ITEMS AND DOLLAR AMOUNTS FOR EACH ITEM)					
23181	TOTAL EQUIPMENT				$	$
	E. MATERIALS AND SUPPLIES					
32630					$	$
	F. DOMESTIC TRAVEL					
42111					$	$
	G. FOREIGN TRAVEL (LIST DESTINATION AND AMOUNT FOR EACH TRIP; GPM 731)					
42112					$	$

NSF Form 1030 (10-77)
PAGE 1 of 2 PAGES

CANCELS NSF FORMS 98, 135, 569 AND 633 EFFECTIVE 10-1-77

SUMMARY PROPOSAL BUDGET

PROPOSAL NO.

52500	H. PUBLICATION COSTS/PAGE CHARGES	$	$
62315	I. COMPUTER (ADPE) SERVICES	$	$
	J. CONSULTANT SERVICES (IDENTIFY CONSULTANTS BY NAME AND AMOUNT; GPM 516)		
		$	$
	K. PARTICIPANT SUPPORT COSTS, IF ALLOWED BY PROGRAM GUIDE (ITEMIZE) GPM 518 1. STIPENDS $ 2. TRAVEL $ 3. SUBSISTENCE $ 4. OTHER - SPECIFY $		
	5. TOTAL PARTICIPANT COSTS (K1 + K2 + K3 + K4)	$	$
	L. ALL OTHER DIRECT COSTS (List items and dollar amounts. Details of subcontracts, including work statements and budget, should be explained in full in proposal.) $ $ $ $		
65001	TOTAL OTHER DIRECT COSTS	$	$
	M. TOTAL DIRECT COSTS (A THROUGH L)	$	$
	N. INDIRECT COSTS (Specify rate(s) and base(s) for on/off campus activity. Where both are involved, identify itemized costs included in on/off campus bases in remarks.)		
74100	TOTAL INDIRECT COSTS	$	$
	O. TOTAL DIRECT AND INDIRECT COSTS (M + N)	$	$
74500	P. LESS RESIDUAL FUNDS (If for further support of current project; GPM 252 and 253)	$	$
75000	Q. AMOUNT OF THIS REQUEST (O MINUS P)	$	$

REMARKS

NOTE: SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233). THIS IS REVISION NO.

SIGNATURE OF PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	DATE OF SIGNATURE	TYPED OR PRINTED NAME AND TITLE
SIGNATURE OF AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	DATE OF SIGNATURE	TYPED OR PRINTED NAME AND TITLE

FOR NSF USE ONLY

INDIRECT COST RATE VERIFICATION			PROGRAM OFFICER APPROVAL
Date Checked	Date of Rate Sheet	Signature	

Grant Number	Amend No.	Institution	Organization	Fund Acct.	Program	Object	

	Proposal Number	Dur.	Chg.	Award Date	Proposed Amount	Propsd. Dur.	

NATIONAL SCIENCE FOUNDATION
Washington, D.C 20550

SUMMARY OF COMPLETED PROJECT

Form Approved
OMB No. 99R0013

Please read instructions on reverse carefully before completing this form.

1. INSTITUTION AND ADDRESS		2. NSF PROGRAM	3. GRANT PERIOD *from* *to*
4. GRANT NUMBER	5. BUDGET DUR. (MOS)	6. PRINCIPAL INVESTIGATOR(S)	7. GRANTEE ACCOUNT NUMBER

8. SUMMARY (Attach list of publications to form)

9. SIGNATURE OF PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR	TYPED OR PRINTED NAME	DATE

NSF Form 98A (12-76) SUPERSEDES ALL PREVIOUS EDITIONS

90%

END

3-9-82